STIMULUS-DEPENDENT ELECTRONIC DEVICE

Field of the Invention

This application relates generally to theft control schemes for portable electronic devices, and more particularly to portable electronic devices employed in a defined setting.

Background of the Invention

Many retail and warehouse facilities disseminate two-way radios among their employees to facilitate their operations. For example, a large retail facility may distribute two-way radios to each of its customer-service personnel, so that they may be alerted in the event that a particular customer is in need of assistance. In such an event, a transmission is broadcast to radios carried by each of the customer-service personnel, and a particular customer service representative responds by transmitting his intention to assist the client in need, so that the remaining representatives can pursue other activities. Two-way radios are used because they promote efficiency, yet are relatively inexpensive, reliable, and allow for simple one-to-many communication.

A particular drawback to the use of two-way radios in retail settings is that they are prone to employee theft. Such theft can prove expensive over time. For example, a major retail store may require as many as fifty or more radios. Over the duration of a year, as much as a third of those radios are stolen by employees (or others) for private use. These radios must be replaced at significant expense to the retailer.

One theft prevention strategy that has been employed in the past is to design the two-way radios to transmit on a first frequency, but receive on a second frequency. Thus, without the aid of another device, none of the radios can receive the transmission of another radio. To permit communication within the retail store, a repeater is employed. The repeater receives the radio transmissions on the first frequency and re-transmits those transmissions on the second frequency, so that they may be received by the radios in the retail space. Once out of range of the repeater, the radios are inoperative, because they are unable to communicate with each other. Thus, the motivation for stealing the radios is eliminated.

The above-described repeater scheme possesses certain drawbacks, however. In a retail setting, two-way radios may be used amongst stock room personnel, amongst security personnel, and amongst greeters. Oftentimes, each group of personnel is assigned their own frequency for transmission (one frequency for security personnel, and another frequency for customer service personnel, for example). For the above-described repeater scheme to work in such a setting, multiple repeaters need to be deployed, each operating on a unique set of frequencies. Such a scheme is expensive to establish and expensive to maintain, because of frequency variations from store to store.

As is evident from the preceding discussion, there is a need for a simple, inexpensive scheme for deterring theft of two-way radios from retail settings. A desirable scheme is able to work with existing radios in a convenient and cost-effective manner.

Summary of the Invention

Against this backdrop the present invention has been developed. A two-way radio may be rendered dependent upon exposure to a stimulus for proper operation, after it has been powered down. Such an electronic device includes operational circuitry of the radio for reception and transmission of a radio signal and a power source that provides power to the operational circuitry. A stimulus-sensitive switch is interposed between the power source and the operational circuitry. The stimulus-sensitive switch is configured to remain closed upon initial exposure to a given stimulus, until such time as the radio is powered down.

According to another embodiment of the invention, a power-up sequence of a two-way radio is governed by a method. The method includes interrupting flow of electrical current from a battery within the radio, with a non-mechanically actuatable switch. Upon initial exposure to a given stimulus, the switch is closed, thereby permitting electrical current to flow from the battery and allowing the power-up sequence to take place.

According to yet another embodiment of the invention, a power-up sequence of a two-way radio with an embedded processor is governed by a method. The method includes instructing the microprocessor to enter an inactive state, upon power-up of the

radio. The microprocessor is instructed to remain in the inactive state, until a particular stimulus is received, thereby rendering the radio non-operational. Finally, upon reception of a stimulus, the microprocessor is instructed to exit the inactive state and to execute a sequence of instructions for operating the radio.

According to yet another embodiment of the invention, deterrence of theft of an electronice device may be achieved according to a method. The method includes rendering operation of a portable electronic device dependent upon a given stimulus, so that the device is inoperable without at least some exposure for some time to the given stimulus. A source of the stimulus is provided within the locality. Transmission of the stimulus is limited to a region of space within the locality.

According to yet another embodiment of the invention, deterrence of theft of an electronice device may be achieved according to a method. The method includes rendering a portable electronic device incapable of properly operating after being powered down, without at least some exposure for some time to a given stimulus during a subsequent power-up sequence. A source of the stimulus is provided within the locality. Transmission of the stimulus is limited to a region of space within the locality.

Brief Description of the Drawings

FIG. **1** depicts a high-level schematic of an electronic device configured to require exposure to an external stimulus for its power-up sequence to proceed.

FIG. **2** depicts a high-level schematic of an electronic device configured to be rendered operational as soon as it is exposed to the stimulus.

FIG. **3** depicts a high-level schematic of an electronic device configured with an on/off switch connected in series with a stimulus-sensitive switch.

FIG. **4** is a more detailed schematic depiction of one embodiment of the invention shown in FIG. **3**.

FIG. **5** depicts a high-level schematic of an electronic device, according to yet another embodiment of the present invention.

FIG. **6** depicts a high-level schematic of an electronic device **100**, according to yet another embodiment of the present invention.

FIG. **7** depicts a sequence of instructions that may be executed by an embedded processor within the device, according to one embodiment of the present invention.

FIG. **8** depicts a system that employs embodiments of the device depicted in FIGs. **1-7**.

FIG. **9** depicts a high-level schematic of a two-way radio, in which exemplary points for introduction of a stimulus-dependent switch are identified.

Detailed Description

Theft of portable electronic devices, such as two-way radios, may be deterred by rendering their power-up sequences dependent upon initial exposure to a pre-determined stimulus. For example, a two-way radio may be designed to possess a stimulus-sensitive switch, such as a hall-effect switch, that remains open until initial exposure to a given stimulus. By inserting that switch in a circuit critical to the operation of the two-way radio (in between the radio's battery and the rest of its circuitry, or in series with the radio's speaker, antenna, microphone, or voltage regulator, for example), the radio is inoperative until it is exposed to the stimulus. The stimulus-sensitive switch may be composed of more than one switch, and may be arranged so that it remains closed (until powering down of the device) after a single, brief exposure to the stimulus. Accordingly, per such a scheme, after a radio has been turned off, it cannot properly function until it is turned on and brought to the source of the stimulus for exposure thereto. By providing the source of stimulus only within the confines of the locality in which the radios are to operate, motivation to steal the radios is eliminated, because, once powered down, the radios will not function until returned to the locality for exposure to the stimulus.

Rendering of a power-up sequence dependent upon exposure to a stimulus need not be accomplished with a switch. Other approaches exist, such as programming the device to enter an inactive state, upon powering up; the device remains in the inactive state, until initial exposure to the stimulus. Of course, if the device is controlled with an application-specific integrated circuit (ASIC), rather than with a processor, the ASIC may be designed with such functionality hard-wired therein. Once again, by providing the source of stimulus only within the confines of the locality in which the radios are to

operate, motivation to steal the radios is eliminated, because, once powered down, the radios will not function until returned to the locality for exposure to the stimulus.

FIG. **1** depicts a high-level schematic of an electronic device **100** configured to require exposure to an external stimulus **102** for its power-up sequence to proceed. The electronic device **100** consists of a power source **104**, a stimulus-sensitive switch **106**, and operational circuitry **108**. The power source **104** provides electrical current to the operational circuitry **108**, so that the device **100** can function. The operational circuitry **108** includes all of the circuitry required for the device **100** to operate. For example, in the case of a two-way radio, the operational circuitry **108** may include transmission, reception, and control circuitry, including amplification, modulation, demodulation, and filtering circuits. For a given electronic device **100**, the circuits **108** required for operation of the device **100** are known in the art and need not be recited herein, as their precise design generally falls outside of the scope of the present invention.

As can be seen from FIG. **1**, the device **100** cannot operate unless the stimulus-sensitive switch **106** is closed (while the switch **106** is open, the operational circuitry **108** is deprived of electrical current). The stimulus-sensitive switch **106** may have many embodiments. For example, the switch **106** may be arranged to close if and only if it is exposed to the given stimulus **102**. Thus, for the device **100** to be operational, the device **100** would have to be in the presence of the stimulus **102** at all times. Alternatively, the switch **106** may be configured to close and remain closed upon an initial exposure to the stimulus **102**. Per such an embodiment, the device **100** would be rendered operational as soon as it was exposed to the stimulus **102**, and it would remain operational until it was powered down.

The stimulus-sensitive switch **106** may be used in conjunction with an on/off switch (not depicted in FIG. **1**; see FIG. **3** for an example of an on/off switch wired in series with a stimulus-sensitive switch **106**). The on/off switch may be wired in series with the stimulus-sensitive switch **106**, so that powering up of the device **100** requires both manually actuating the on/off switch, and exposing the device **100** to the stimulus **102**. Alternatively, the stimulus-sensitive switch **106** may stand alone, so that the device commences its power-up sequence as soon as it is exposed to the stimulus **102**. Such a

device **100** could be powered down by manual actuation of an off switch (not depicted in FIG. 1).

Various forms of stimuli **102** may be used to activate the switch **106**. For example, the stimulus-sensitive switch **106** may be a hall-effect switch, which closes in response to immersion in a magnetic field. In such a case, the stimulus **102** is a magnetic field. Other forms of stimulus may be used, as well. For example, the stimulus **102** may be a radio frequency (RF) transmission, an infrared (IR) transmission, a pulsed magnetic field, or any other form of transmittable energy. Additionally, the switch **106** may require an identification code to be modulated with the RF, IR, or pulsed magnetic transmission, in order for it to close.

FIG. **2** depicts a high-level schematic of an electronic device **100** configured to be rendered operational as soon as it is exposed to the stimulus **102**. The device depicted in FIG. **2** remains operational thereafter, until it has been powered down.

As shown in FIG. **2**, the stimulus-sensitive switch includes more than one switch **108** and **110**. Per the embodiment shown in FIG. **2**, a first switch **108** is configured to close in response to exposure to the stimulus **102**. Closure of the switch **108** permits electrical current to pass through the switch **108** and into a disjunctive summing circuit **112**. The disjunctive summing circuit **112** provides an ouput signal, if and only if one of its inputs is asserted. Thus, closure of the first switch **108** results in an output from the summing circuit **112**, which, in turn, results in closure of the second switch **110**. Closure of the second switch **110** has two effects. First, electrical current is allowed to flow to the operational circuitry **108** of the device **100**, so the device is rendered operational. Second, electrical current is fed back into a second input of the disjunctive summing circuit **112**, thereby producing an output therefrom, and thereby causing the second switch **110** to remain closed. Accordingly, the stimulus-sensitive switch **106** depicted in FIG. **2** remains closed after a single, brief exposure to the stimulus **102**. Consequently, the device **100** remains operational thereafter, until such time as it is powered down.

FIG. **3** depicts a high-level schematic of an electronic device **100** configured with an on/off switch **114** connected in series with the stimulus-sensitive switch **106**. Powering up of this device **100** requires two actions. First, the on/off switch **114** must be manually actuated to the "on" position. Second, the device **100** must be exposed, for a

single, brief period to the stimulus **102**. Thereafter, current flows as described in the embodiment of FIG. **2**, and the device **100** remains operational, until it is powered down. Per this embodiment, the device **100** may be powered down by manual actuation of the on/off switch **114** to the "off" position.

FIG. **4** is a more detailed schematic depiction of one embodiment of the invention shown in FIG. **3**. As in FIG. **3**, the power source **104**, stimulus-sensitive switch **106**, operational circuitry **108**, and on/off switch **114** are connected in series. In this embodiment, the stimulus-sensitive switch **106** is designed to remain closed after an initial, brief exposure to the stimulus **102**.

As shown in FIG. **4**, the stimulus-sensitive switch **106** includes a hall-effect switch **400**. The hall-effect switch **400** contains three pins: inputs **400a** and **400b**, and output **400c**. When immersed in a magnetic field, the hall-effect switch **400** closes, so that inputs **400a** and **400b** are connected to output **400c**. Thus, when closed, current flows through the switch **400**, through the output pin **400c**, and to an input pin **402a** of integrated circuit **402**. The integrated circuit **402** is a single chip containing three field effect transistors (FETs), two of which are shown in FIG. **4**. The input pin **402a** is connected to the gate of each FET **404** and **406** within the integrated circuit **402**. The power supply **104** is coupled to the source of each FET **404** and **406**, through input pins **402b** and **402c**. Thus, when the hall-effect switch **400** is immersed in a magnetic field, a voltage is developed on the gate of each FET **404** and **406**. Consequently, a conduction path within each FET **404** and **406** is created, permitting current to flow through each FET **404** and **406** and to the operational circuitry **108**, via output pins **402d** and **402e** (which are connected to the drains of the FETs **404** and **406**). A second consequence of current flowing through the FETs **404** and **406** is that the current is permitted to flow back through the diode **412**, returning to the input pin **402a**, thereby keeping both FETs "on." The resistors **414** and **416** cooperate to form a voltage divider, ensuring that the voltage present at input pin **402a** exceeds the threshold voltage of the FETs, so that they will be kept "on." Capacitors **408**, **418**, and **410** are connected between ground and the gates, sources and drains of the FETs **404** and **406** for the purpose of suppressing transient effects.

Although the embodiment depicted in FIG. **4** shows two FETs **404** and **406** connected in parallel as the means of passing current to the operational circuitry **108**, any number of FETs may be connected in parallel to accomplish this task (the greater the number of FETs connected in parallel, the greater the total current delivering capacity). Furthermore, other forms of switches may be used in place of the FETs **404** and **406**, including switches made from more than one FET, switches made from a single bipolar junction transistor (BJT), or switches made from multiple BJTs.

FIG. **5** depicts a high-level schematic of an electronic device **100**, according to yet another embodiment of the present invention. As in previous embodiments, the power source **104**, stimulus-sensitive switch **106**, operational circuitry **108**, and on/off switch **114** are connected in series. In this embodiment, the stimulus-sensitive switch **106** is designed to remain closed after an initial, brief exposure to the stimulus **102**.

The stimulus-sensitive switch **106** of FIG. **5** is composed of a first switch **500**, a microprocessor **502**, and a second switch **504**. When the first switch **500** is exposed to the stimulus **102**, the switch **500** closes, thereby permitting current to pass to the microprocessor **502**. In response to having received the current, the microprocessor **502** may be programmed to deliver an output signal to the second switch **504**, causing that switch **504** to close. Because the second switch **504** is interposed between the power source **104** and the remainder of the device's circuitry **108**, the remainder of the circuitry **108** is supplied with power, thereby permitting proper operation of the device **100**.

One skilled in the art understands that the interface between the first switch **500** and the microprocessor **502** may involve signal-conditioning circuits (level shifters and the like), which are known in the art. The interface may be accomplished through connection with an input port of the microprocessor **502**. Similarly, one skilled in the art understands that the interface between the microprocessor **502** and the second switch **504** may take place via an output port, and may involve use of a driving circuit for generating the proper voltage/amperage to close the switch **504**.

Optionally, the microprocessor **502** may be programmed to require a pre-determined sequence of input pulses before commanding the second switch **504** to close. For example, the first switch **102** may be a hall-effect switch, which closes in response to immersion in a magnetic field. The microprocessor **502** may require the magnetic field

to be pulsed in a predetermined sequence, before commanding the second switch **504** to close. Thus, per such an embodiment, a coded stimulus **102** may be implemented for activating the device **100**.

One skilled in the art understands that the microprocessor **502** may be embodied as an ASIC that is hardwired to perform the above-described functionality.

FIG. **6** depicts a high-level schematic of an electronic device **100**, according to yet another embodiment of the present invention. As in previous embodiments, the power source **104**, stimulus-sensitive switch **106**, operational circuitry **108**, and on/off switch **114** are connected in series. In this embodiment, the stimulus-sensitive switch **106** is designed to remain closed after an initial, brief exposure to the stimulus **102**.

The stimulus-sensitive switch **106** of FIG. **6** is composed of reception circuitry **600** coupled to a microprocessor **502** that is interfaced with a switch **602**. The switch 602 is interposed between the power source **104** and the remainder of the device's circuitry **108**. The reception circuitry **600** may include an antenna, demodulation/recovery circuitry, filtering circuitry, and interface circuitry (such as an analog-to-digital converter) to permit the received data to be communicated to the processor **502**. Such circuitry is known in the art and requires no further explanation. The microprocessor **502** may be programmed to await a particular stimulus signal **102** before commanding the switch **602** to close (thereby providing electrical current to the remainder of the circuitry **108**). For example, the stimulus **102** may be an IR or RF signal upon which a specific code is modulated. In such a case, the reception circuitry **600** demodulates the received stimulus **102** and communicates the recovered code to the microprocessor **502**. The microprocessor **502** may be programmed to await reception of a certain code (such as a code identifying the particular device) before commanding the switch **602** to close. Thus, each device (such as a two-way radio) may have an identification code stored in memory; the micrprocessor **502** does not close the second switch **602** until receiving a code that matches the particular identification code stored in memory.

FIG. **7** depicts a sequence of instructions **700** which may be executed by an embedded processor within the device **100**, according to one embodiment of the present invention. According to this embodiment, the device **100** includes an embedded processor that controls the operation of the device **100**. The processor referred to may be

the microprocessor **502** depicted in FIGs. **5** and **6**, or may be included as part of the operational circuitry **108** depicted in FIGs. **1-6**.

As can be seen from FIG. **7**, upon power up, the embedded processor may be programmed to enter an inactive state **702**, in which the processor is dormant until reception of the stimulus **102** is announced to the processor. In query operation **704**, the microprocessor determines whether the stimulus **102** has been received. If not, the microprocessor returns to its inactive state **702**. If, on the other hand, the stimulus **102** has been received, the processor is permitted to execute the remainder of the software/firmware **706** required for normal operation of the device **100**. Accordingly, the device is rendered non-functional until a brief, initial exposure to the stimulus **102**. Thereafter, the device **100** remains functional, until powered down.

FIG. **8** depicts a system **800** that employs embodiments of the device **100** depicted in FIGs. **1-7**. The system **800** includes a locality **802** in which the electronic devices **804**, **806**, and **808** are to operate. For example, the locality **802** may be a retail space or a warehouse. The system **800** discourages removal of the devices **804**, **806**, and **808** from the locality **802**. Further included in the system **800** is a stimulus source **810**, which provides a stimulus **102** that is used to permit the various devices **804**, **806**, and **808** to operate properly after having been powered down. The devices **804**, **806**, and **808** may be designed according to the embodiments depicted according to FIGs. **1-7**.

The stimulus source **810** produces a stimulus **102** used to activate the devices **804**, **806**, and **808**, as discussed throughout the application. The stimulus **102** may take the form of an electromagnetic signal that propagates through space. If so, the signal should be confined to extend not further than a region of space approximately coextensive with the locality **802** in which the devices **804**, **806**, and **808** are to operate. Alternatively, the stimulus source **810** may be designed to transmit such a stimulus **102** in a region of space **814** immediately surrounding the source **810**. As a third alternative, the stimulus **102** may be confined to a region of space **812** within the source **810**, itself. Per such an embodiment, a device **804**, **806**, and **808** is partially inserted into the source **810** for exposure to the stimulus **102**.

As described earlier, the system **800** eliminates the motivation to steal the devices **804**, **806**, and **808**, because, once powered down, the devices **804**, **806**, and **808** must be brought to the stimulus source **810** to be rendered operational.

FIG. **9** depicts a high-level schematic of a two-way radio **900**, in which exemplary points **918a-h** for introduction of a stimulus-dependent switch **106** are identified.

The radio **900** includes a power source **902**, such as a battery or battery pack, coupled to a voltage regulator **906** through an on/off switch **904**. The voltage regulator maintains a particular voltage on power lines within the radio **900**. For example, digital logic oftentimes runs off of five-volt power lines. Thus, the voltage regulator **906** may be designed to yield a five-volt output, with which the circuitry within the radio **900** is powered. In the particular embodiment depicted in FIG. **9**, the voltage regulator **906** provides power to a processor **908** and to transmission/reception/synthesizing circuitry **910**.

The processor **908** provides general control for the two-way radio, and is an exemplary site for execution of the method described with reference to FIG. **7**. The processor **908** controls such features as the frequency of transmission and/or the introduction sub-audible tones into the transmission stream. As can be seen from FIG. **9**, the processor **908** communicates data to the transmission/reception/synthesizing circuitry **910**, which operates based upon the data received therefrom. For example, the transmission/reception/synthesizing circuitry **910** generates a carrier frequency and modulates voice data against that frequency, based upon data from the processor **908**.

The transmission/reception/synthesizing circuitry **910** generally performs the tasks necessary for transmission and reception of a radio signal, including production of a carrier signal, modulation, demodulation, amplification, and filtering of transmission and reception signals. The transmission/reception/synthesizing circuitry **910** is coupled to: (1) a microphone **912** for reception of voice data to be modulated against the carrier signal; (2) a speaker **914** for transducing the received and demodulated reception signal into a sound signal; and (3) an antenna **916** for reception and transmission of radio signals.

Broadly speaking, a stimulus-sensitive switch **106** may be interposed in any operation-critical path in a two-way radio **900** (or any other device, for that matter). Such

operation-critical sites include, but are not limited to: placement in series with the voltage regulator **906**, as shown by reference numerals **918a** and **918b**; placement in series with the power supply lines for the transmission/reception/synthesizing circuitry **910** or the processor **908**, as shown by reference numerals **918d** and **918c**, respectively; placement in series with the speaker, as shown by reference numeral **918e**; placement in series with the microphone **912**, as shown by reference numeral **918f**; placement in series with the antenna, as shown by reference numeral **918g**; or placement in series in the data path between the processor **908** and the transmission/reception/synthesizing circuitry **910**, as shown by reference numeral **918h**.

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. For example, the system and devices disclosed herein may utilize any form of stimulus suitable for effective transmission. Additionally, transmission of the stimulus itself may be rendered conditional on an event, such as identification of the particular electronic device to which the source is to transmit the stimulus (for example, the electronic device may be outfitted with an RF identification tag that permits the source to identify the particular device). Per such a modification, the source would transmit the stimulus only if the identification code contained in the RF identification tag was found in a list of approved identification codes. One skilled in the art recognizes that the invention disclosed herein can be used in conjunction with any portable electronic device, including, but not limited to, cordless telephones, cellular telephones or handheld scanners. Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.